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(54) Apparatus and method for collecting subsea oil leakage and the like

(57) In offshore oil production, inadvertent oil leakages such as occurs at so called blow-outs can have very serious economic and pollution effects. The present invention provides an improved technique for dealing with such leakages and comprises the use of a submersible collector vessel having integral therewith effective oil separation equipment. In particular the vessel is located at the leakage zone for example by anchoring or by securement to an oil rig leg, so that the leakage oil can flow into the vessel wherein both the oil and gas are separated from the entrapped water, and the vessel has means permitting the connection of pipelines to deliver the separated oil and gas to suitable disposal/collection members or vessels at the sea water surface. Secondary separation of the oil may be carried out in one of these collection vessels, if necessary.

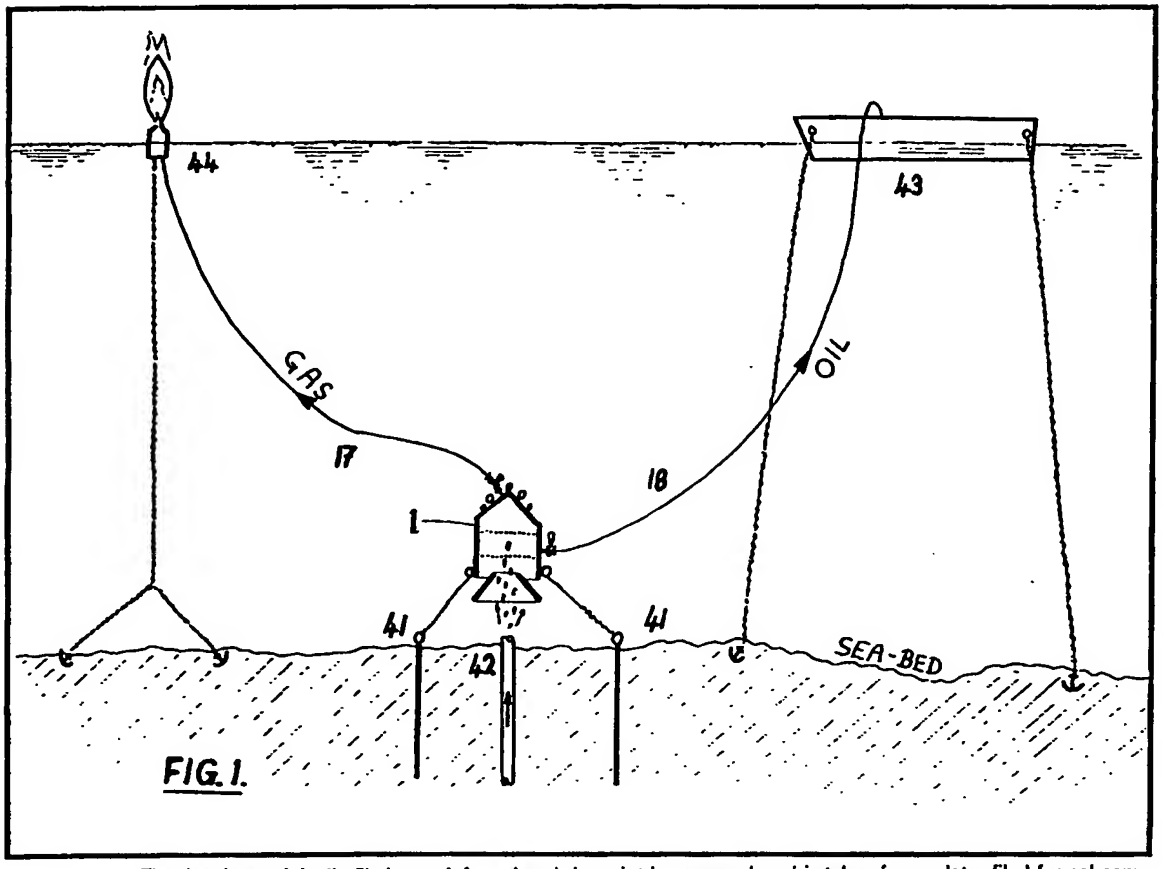

FIG. 1.

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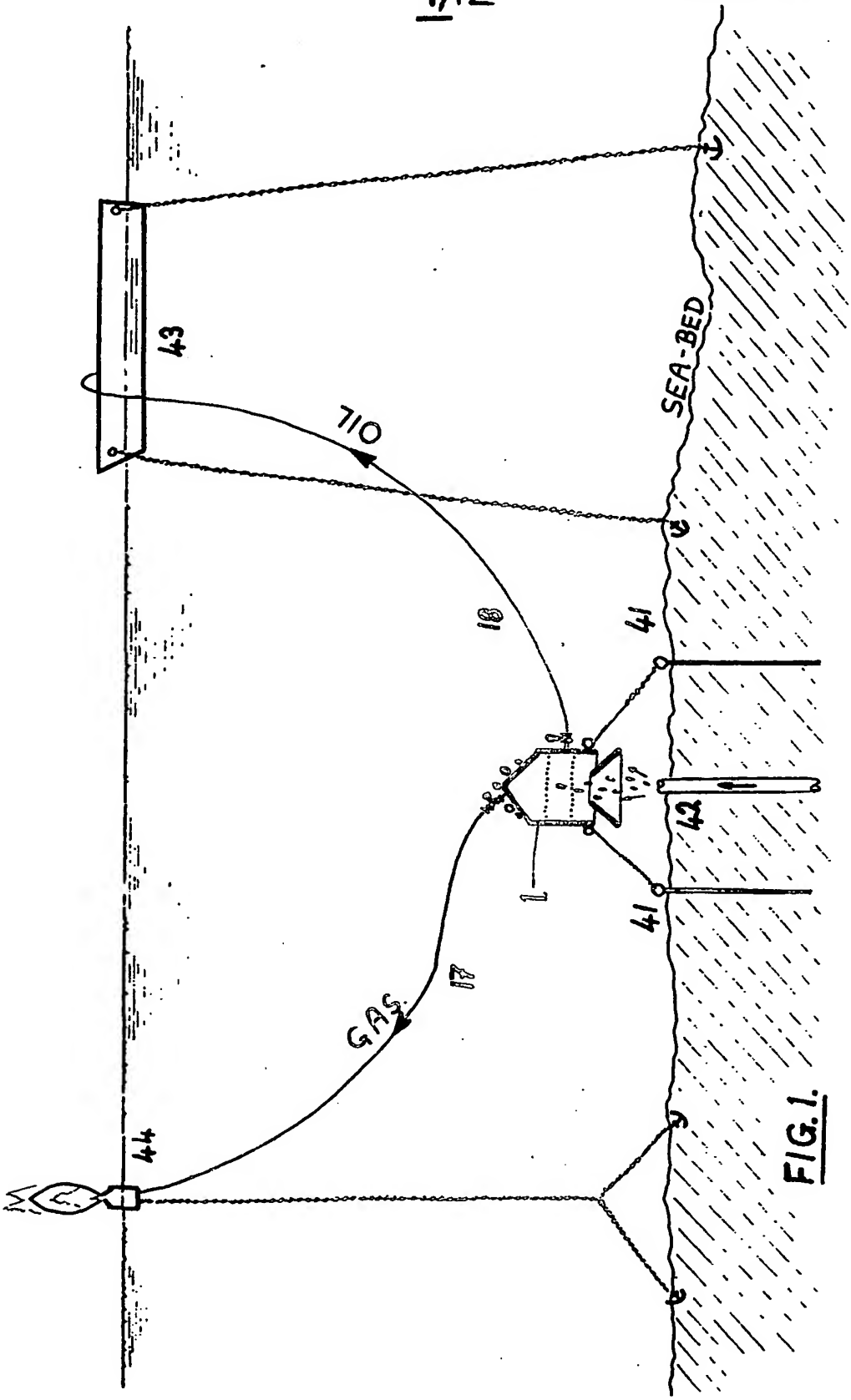


FIG.1.

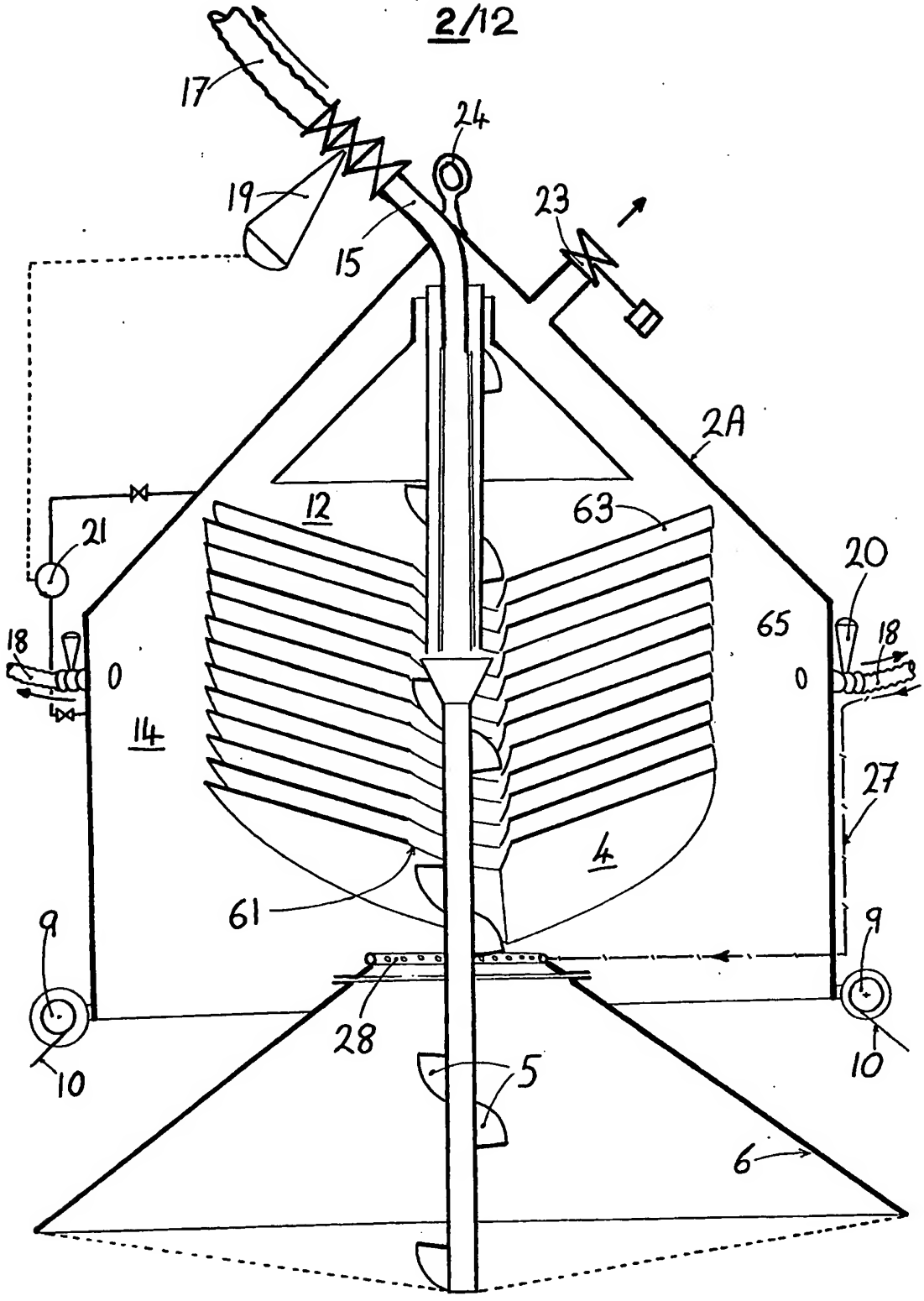


FIG. 2.

SECTION Q-Q

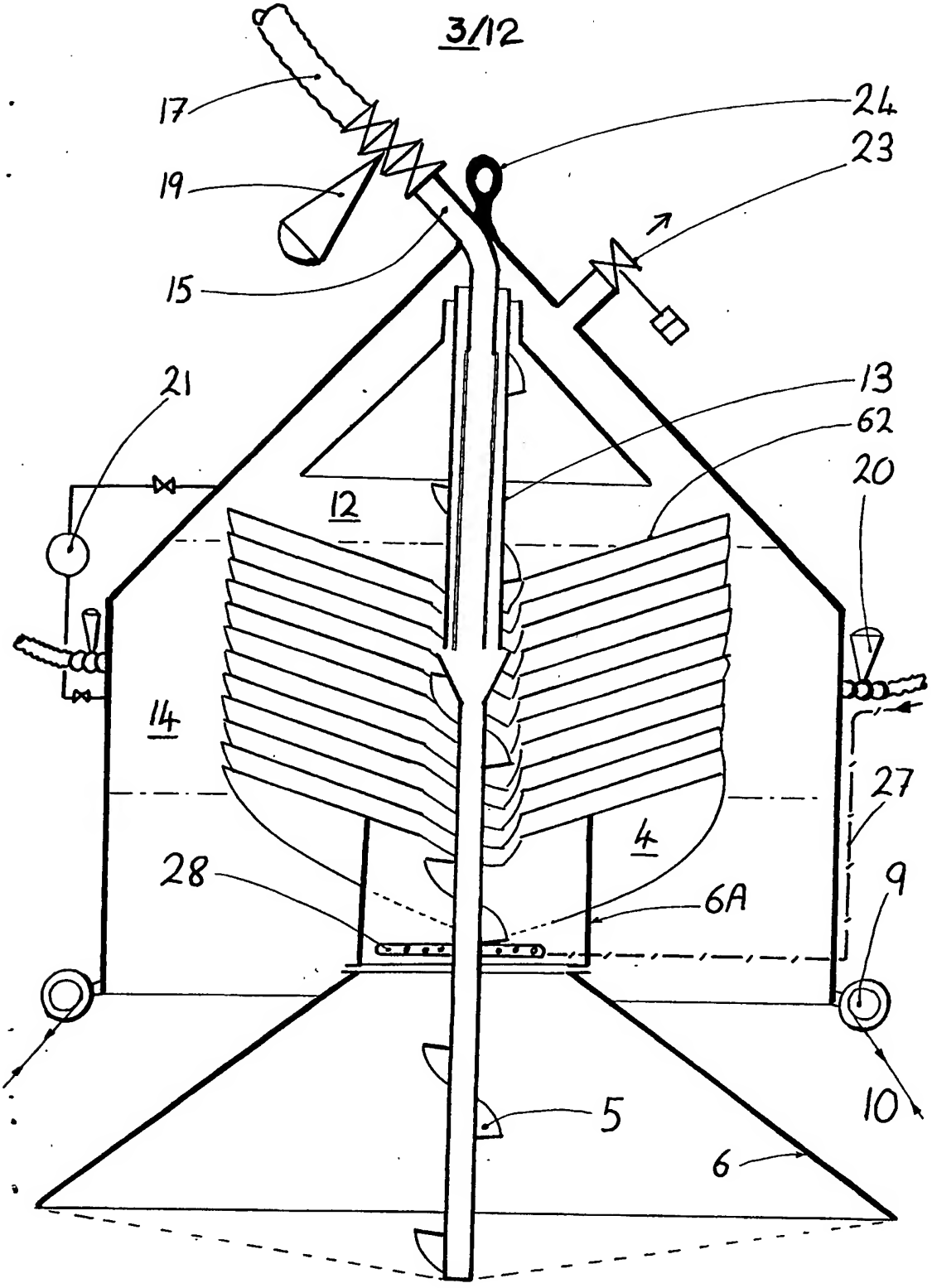


FIG. 2a.

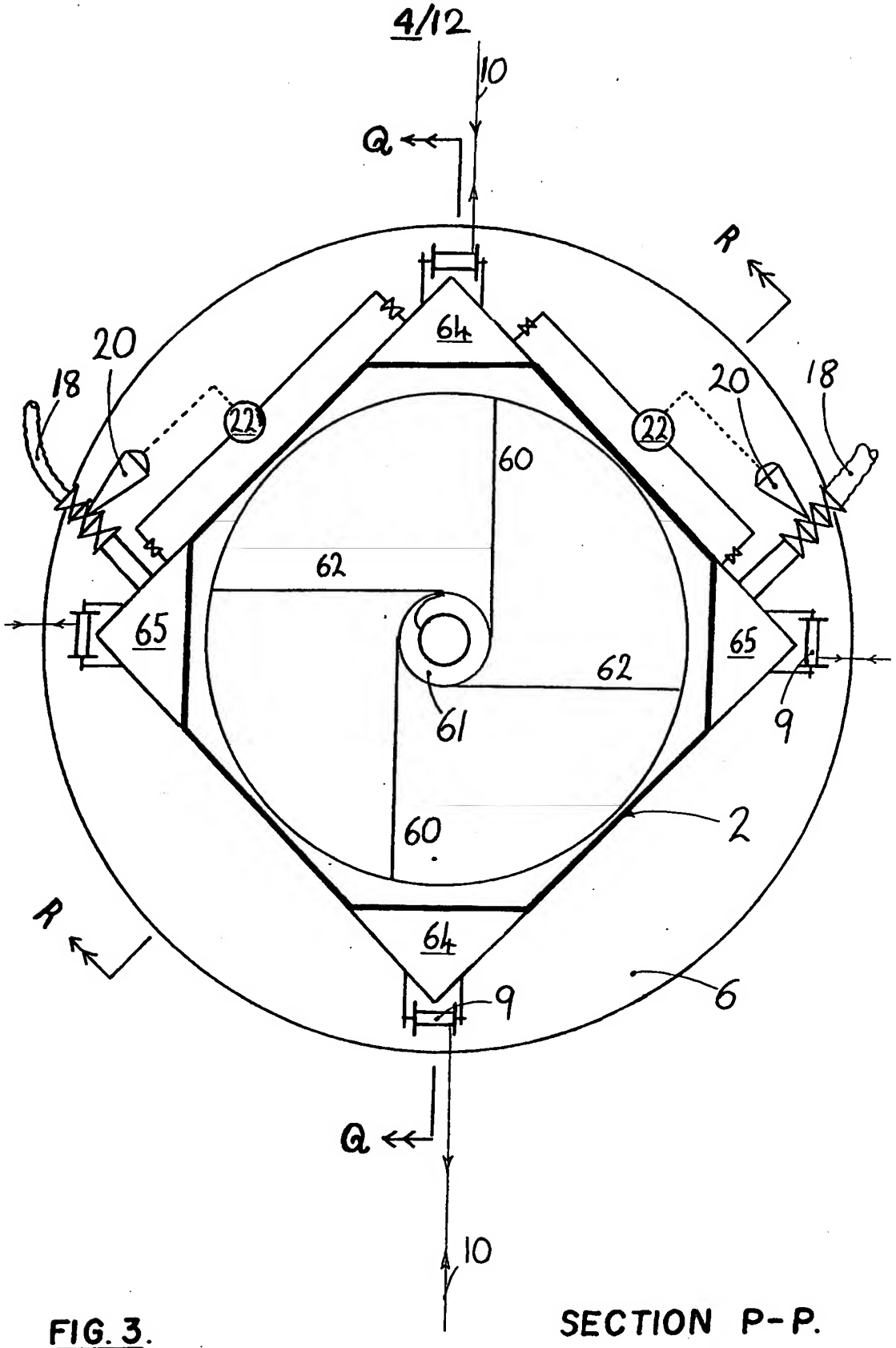


FIG. 3.

SECTION P-P.

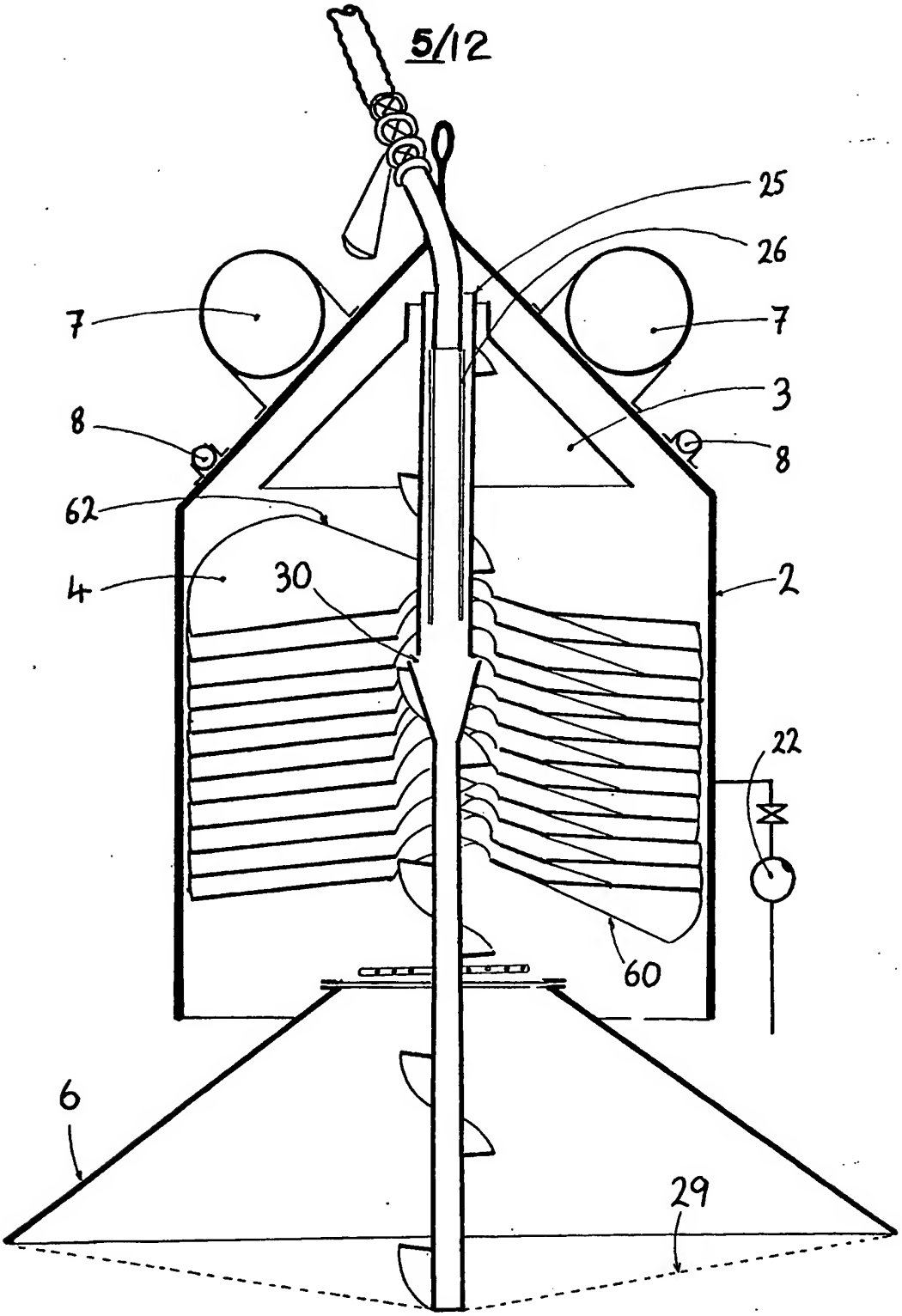


FIG. 4. SECTION R-R.

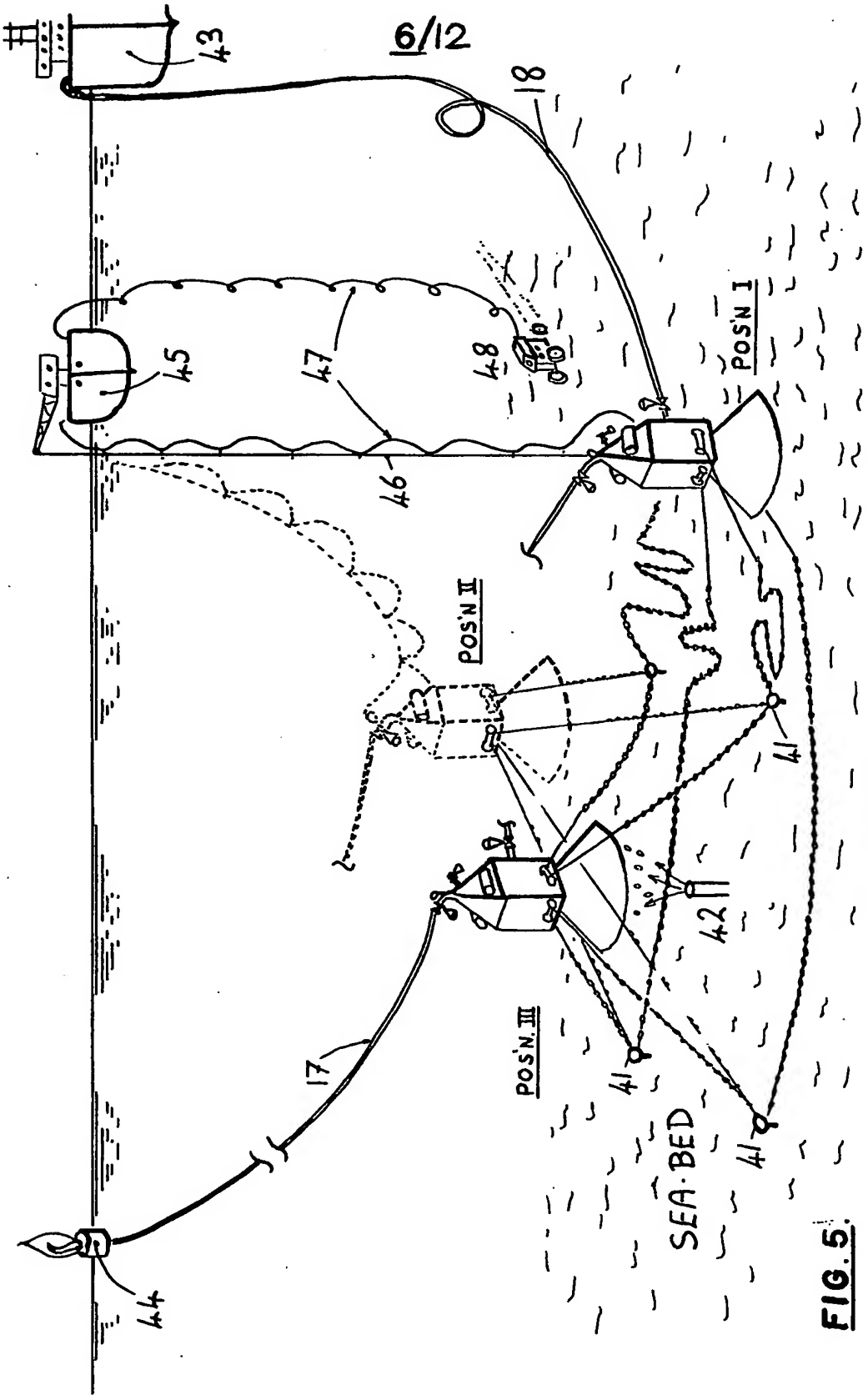
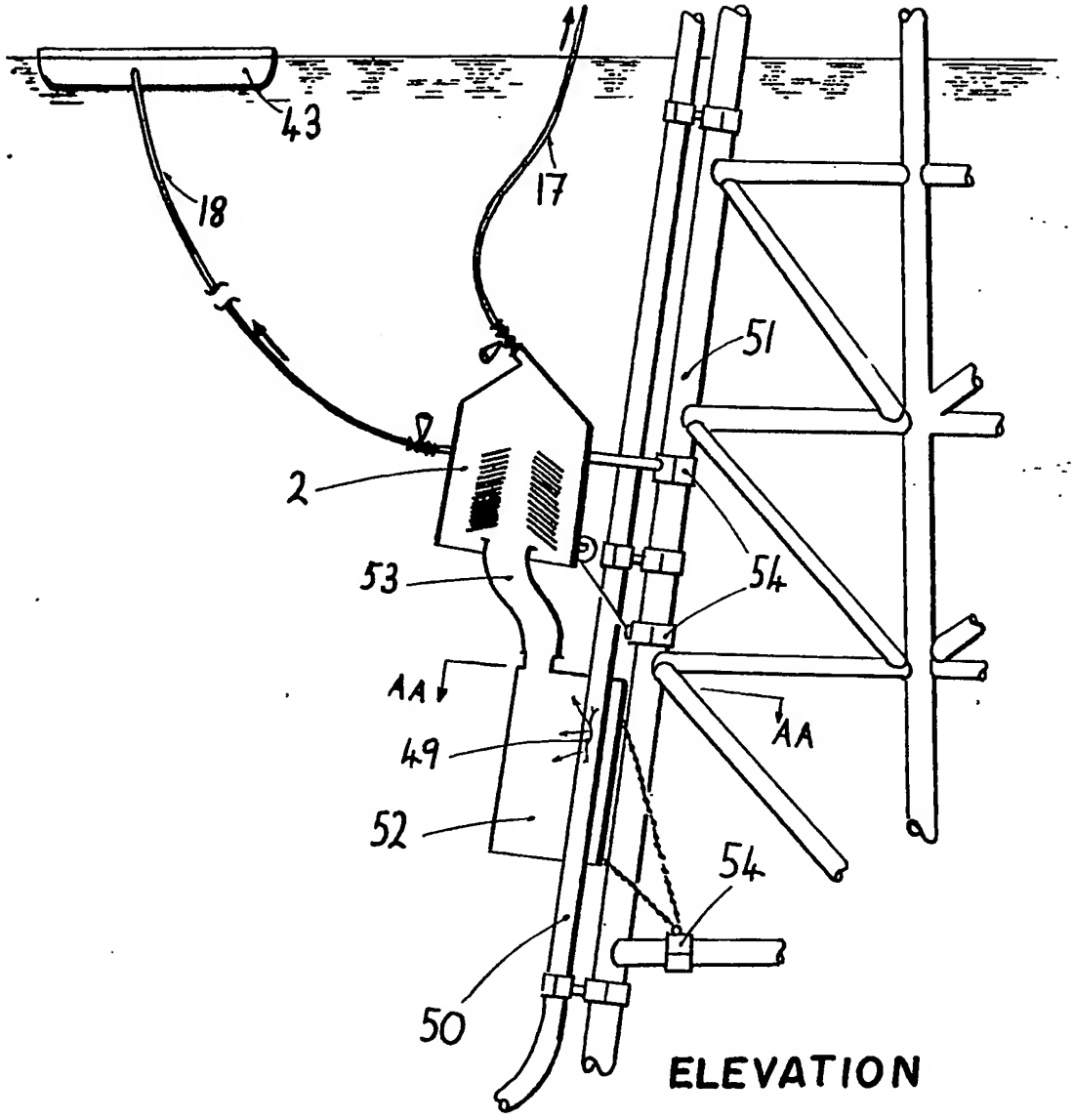
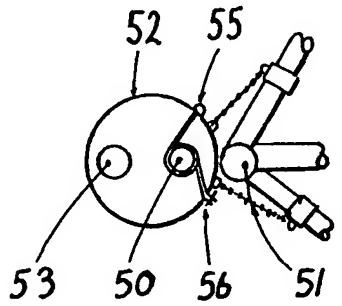


FIG. 5.



ELEVATION



SECTION A-A.

FIG. 6.

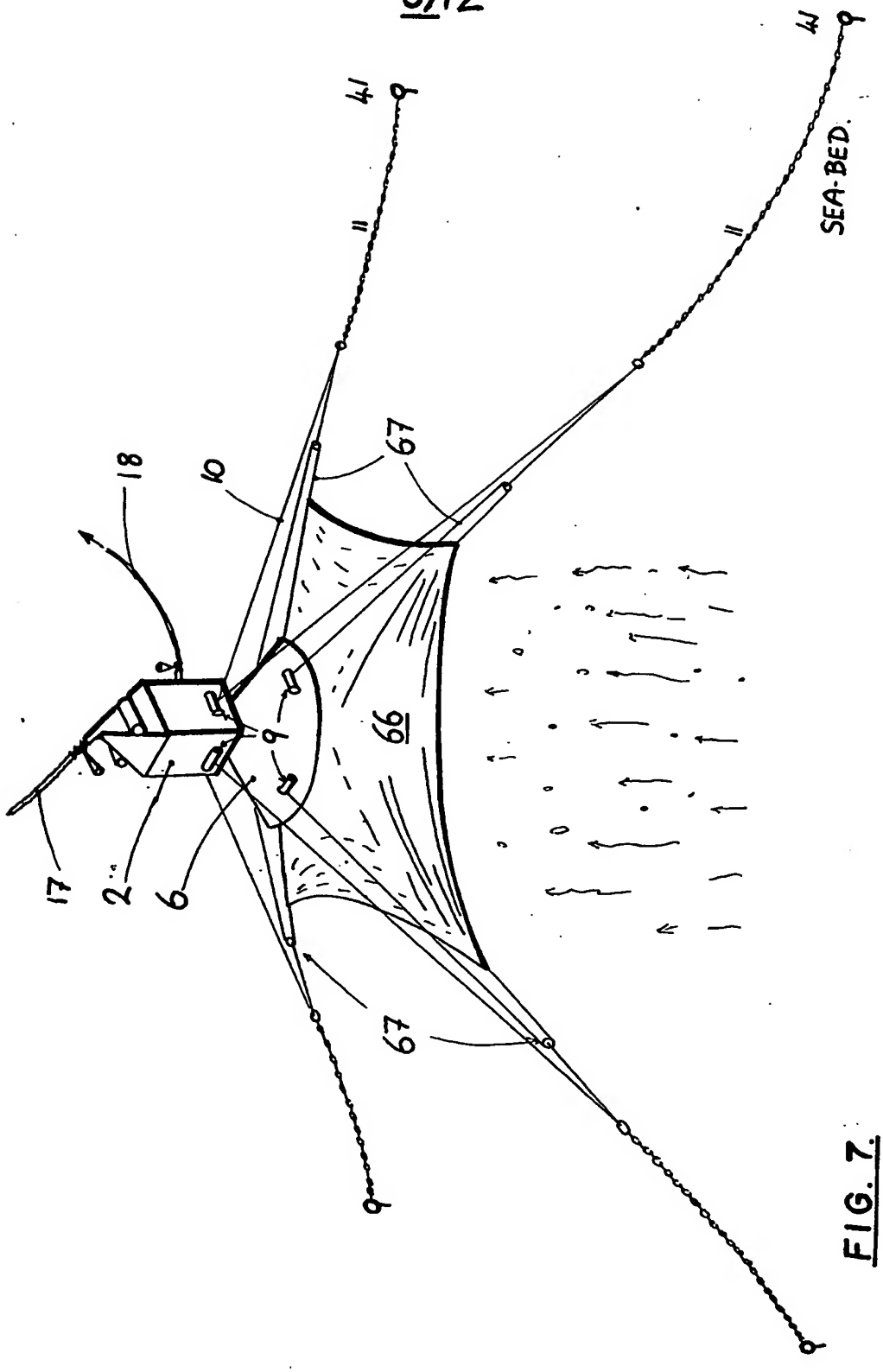


FIG. 7.

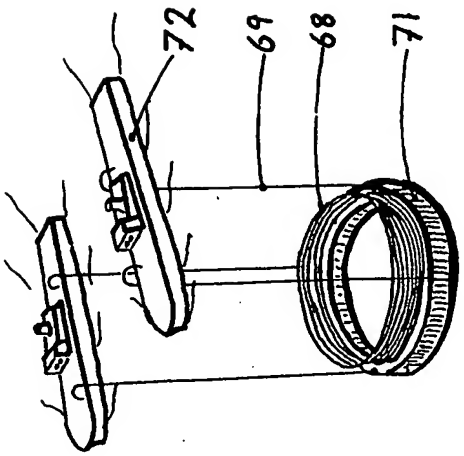


FIG. 8a.

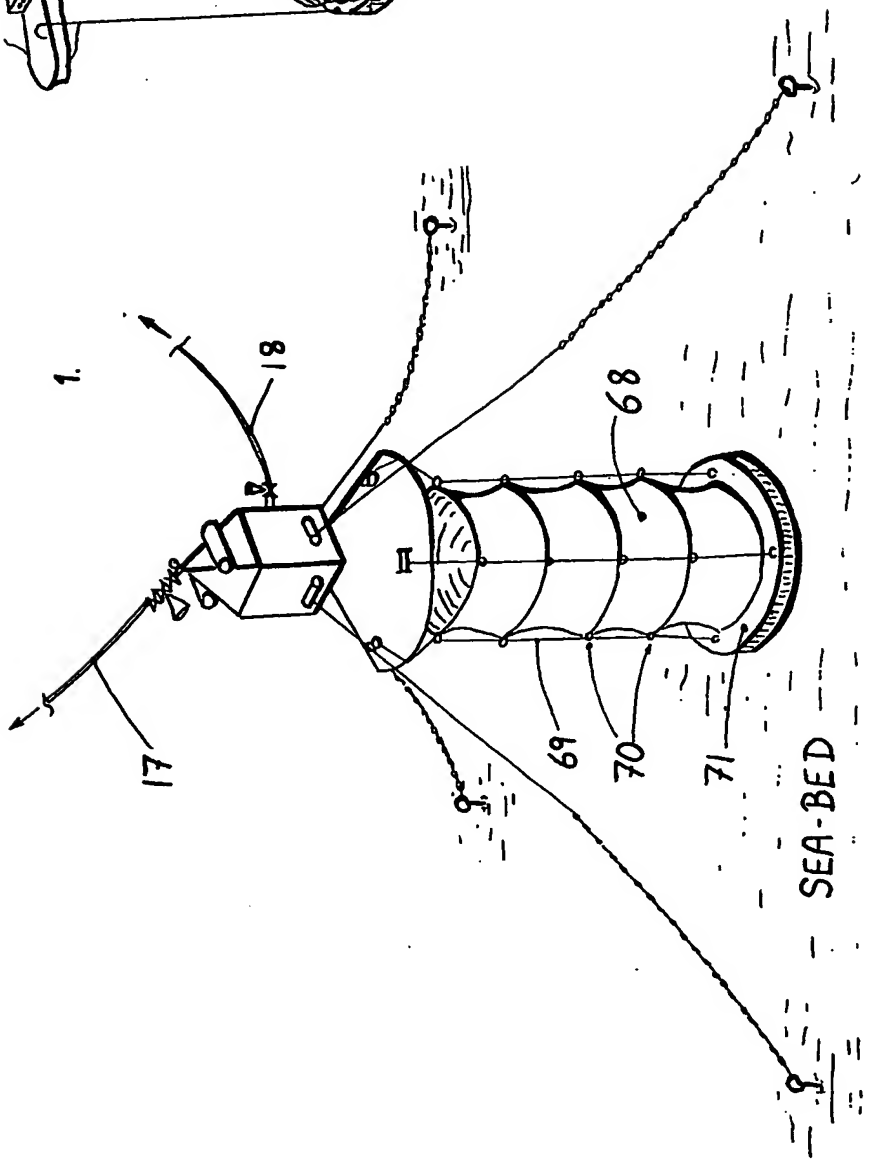


FIG. 8b.

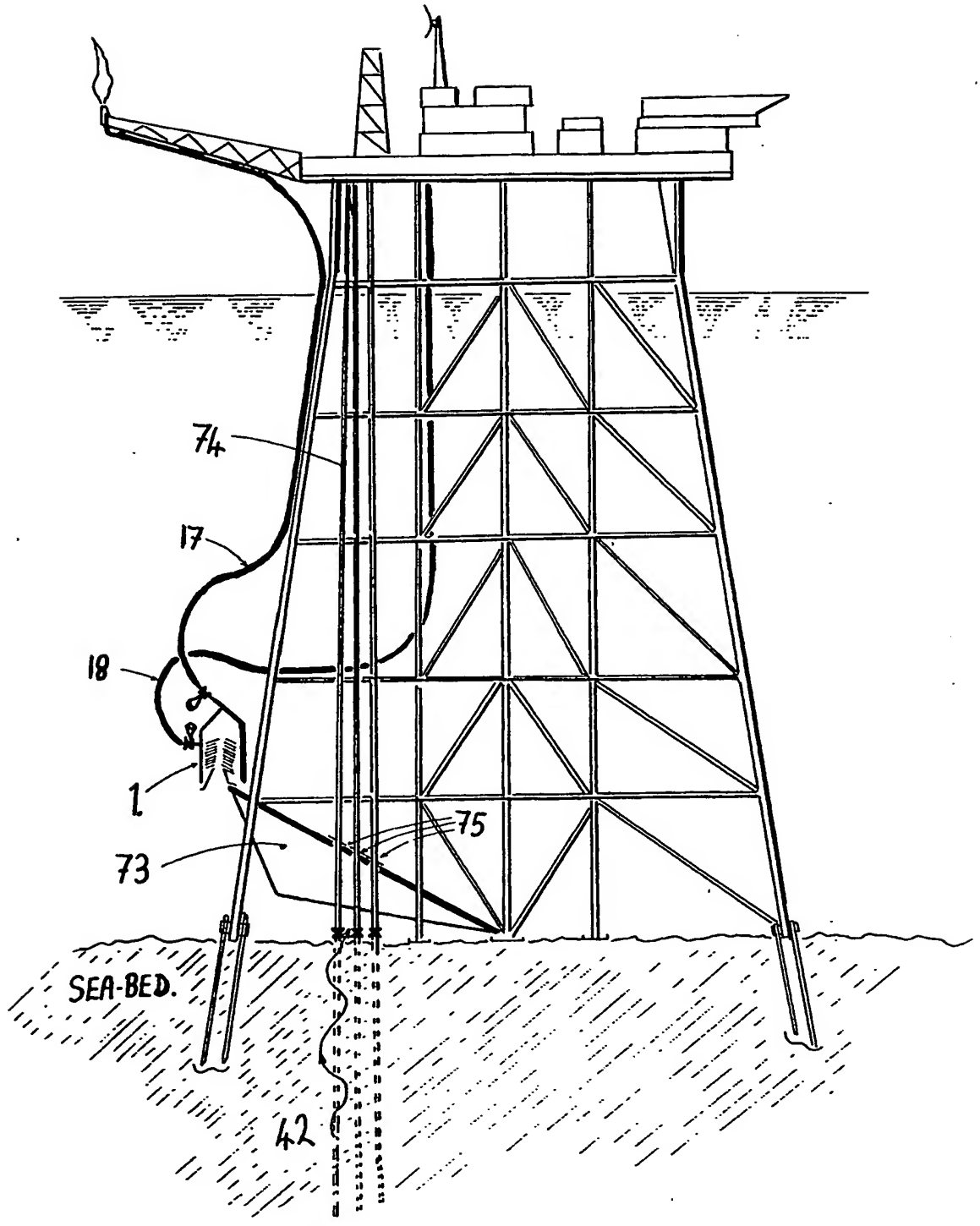


FIG. 9.

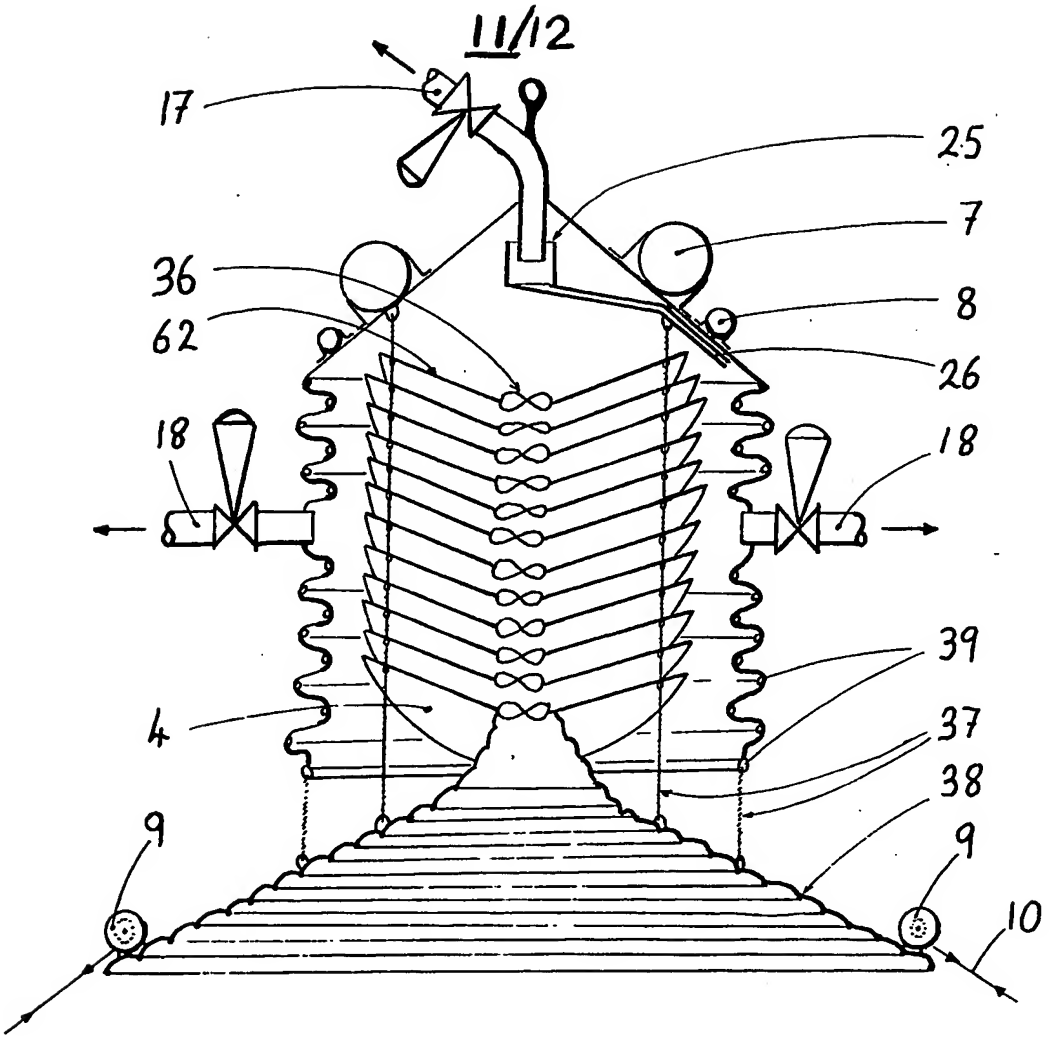


FIG. 10.

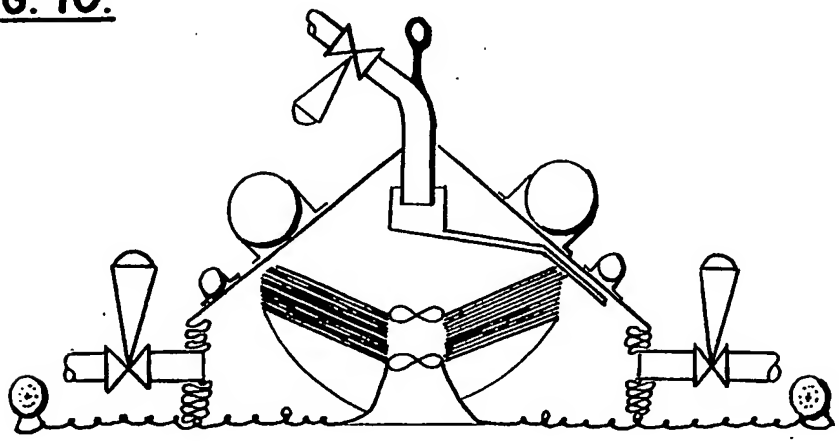


FIG. 11.

SECTION X-X.

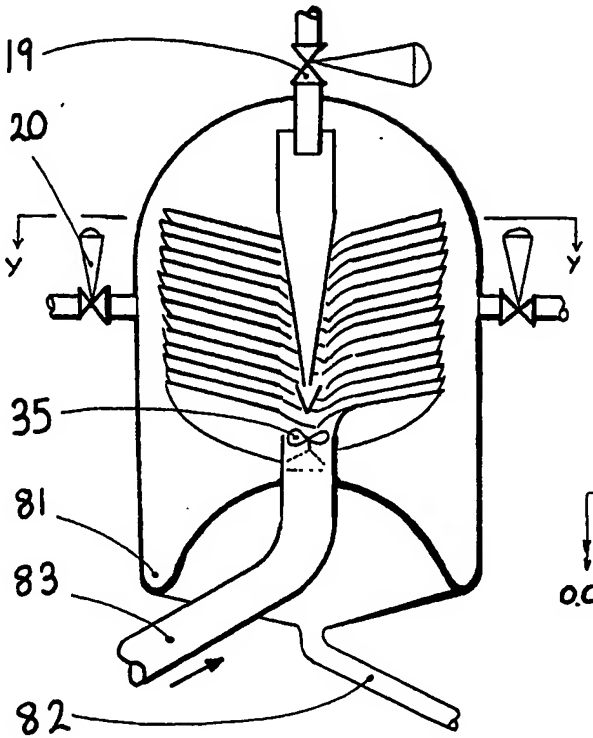


FIG. 12.

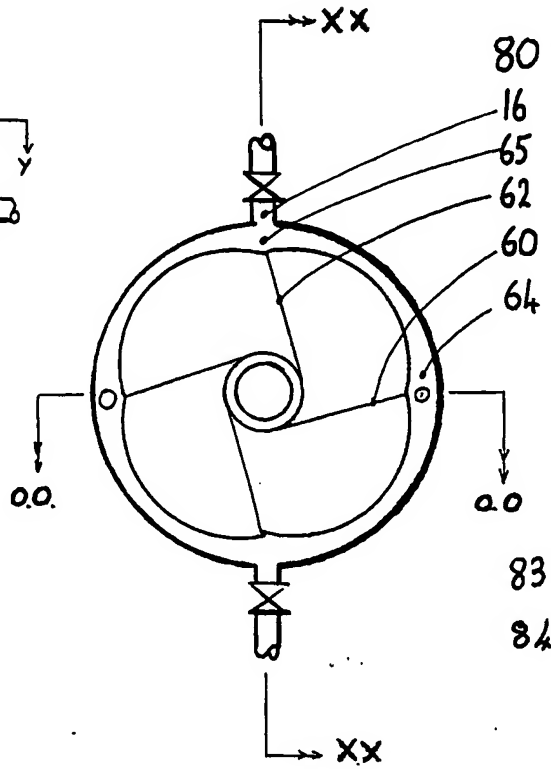


FIG. 13.

SECTION O-O.

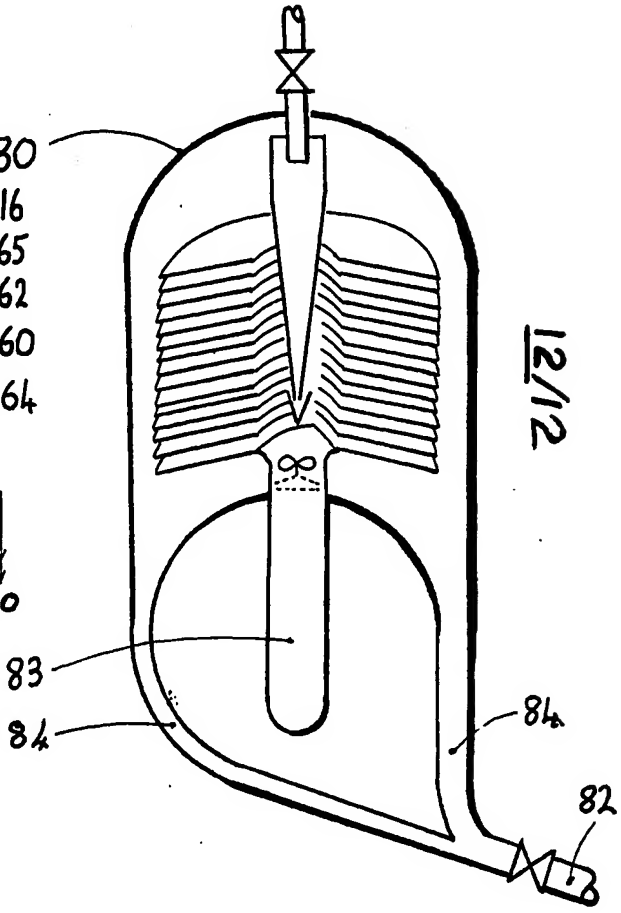


FIG. 14.

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SPECIFICATION

Apparatus for collecting subsea issuing or leakage oil and the like and method for carrying out same.

The present invention is concerned with apparatus for collecting oil and gases which are issuing during production or escaping from an offshore well or equipment. In particular, the present invention provides subsea gas/oil gathering apparatus which may be used in the event of oilrig blow-outs, or other leakages. leakages.

In offshore oil drilling, failure of the well pressure containment can occur (referred to as a blow-out) with very serious economic and pollution consequences, and normally to deal with this situation an auxiliary drilling is effected closely adjacent the failed well line and a fresh well pipe installed to top off the oil from the field so as to by-pass the failed line. Steps can be taken to permanently block the well. These emergency procedures can take considerable time to put into operation, and as an interim measure a floating boom can be used to gather the leakage oil. However, where the well is at a considerable depth the leakage oil can take a considerable time to rise to the surface, the leakage gas on the other hand rises almost directly above the well and if the sea current is strong the leakage oil will surface a substantial distance downstream from the well platform and oil capture by the boom in these circumstances can be difficult. Bad weather and rough seas also hinder boom collection. Diving in the area immediately around the well head is dangerous due to the local in-rushing water currents which are generated by the rising gas bubbles; and the water depth can also hamper diving. There can be substantial amount of debris on the sea bed around the well head area. Both these factors make the installation of any permanently fitted recovery equipment difficult. It is an object of the present invention to obviate or mitigate these disadvantages.

According to one aspect of the present invention there is provided a method of gathering gas, oil and like substances from a subsea leakage or production issuing zone comprising submersing a collecting vessel and mooring or fixing the vessel closely adjacent the point of issuance or leakage, permitting the issuing substances to flow from the issuance or leakage zone into the collecting vessel, causing separation of substances in the vessel and delivering separated substances from the vessel to a storage or disposal means.

According to a further aspect of the present invention, apparatus for collecting subsea production issuing or leakage oil, gas and like substances comprises a vessel for submersion in the sea including means for locating the vessel adjacent the zone of issuance or leakage, collecting means in the vessel for collecting substances issuing at said zone, means for separating issuing substances from sea water and means for connecting a pipeline to the vessel to permit collected substances to be delivered from the vessel to a storage, transportation or disposal means.

The vessel preferably comprises an open bottomed vessel, and said means for locating the vessel can include attachment members for attaching mooring cables to the vessel.

The separating means preferably comprise a vertical array of plates each defining a series of troughs and open bottomed channel. The troughs and channels can be inclined from the horizontal, so that in the separation of oil from sea water, oil will flow up the open bottomed channels of one plate to a collecting zone while water will descend in the troughs of the adjacent lower plate.

Preferred separation apparatus is in the form of a vertical array of annular undulating (petal) plates, each plate having a central aperture through which issuing substances flow, the undulations on each plate being arranged such that there are provided a pair of opposed downwardly inclined troughs on the plate upper surface and a pair of opposed upwardly inclined open bottomed channels on the plate bottom surface.

Preferably the separation means is associated with a vortex, inducing spiral means, and these vortex inducing means can be located on a vertical column preferably extending upwardly through the central apertures of the annular undulating plates.

Preferably the vessel includes buoyancy means to assist location of the vessel at the desired depth. A frusto-conical or other suitable inlet mouth can be provided at the vessels open bottom to assist collection of substances.

Preferably means are provided for applying treatment material to the mixture of substances to be separated, prior to entry to the separation means. Such treatment material may be for example demulsifying agents, and application can conveniently be by means of injection equipment.

The present invention is also separation equipment for material treatment apparatus including a vertical array of annular plates each providing radially and downwardly directed troughs on an upper surface and radially and upwardly directed channels on the plates lower surface.

Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings in which:—

Figure 1 shows a schematic view of a collector/separator apparatus according to the present invention positioned for collecting leakage oil at the seabed.

Figure 2 is a sectional elevation of the collector/separator apparatus of Fig. 1 to a larger scale and through section Q–Q in Fig. 3 while *Figure 2A* shows a similar view of slightly modified separator apparatus.

Figure 3 shows a sectional plan view of the apparatus of Fig. 2 through section P–P in Fig. 2;

Figure 4 shows a sectional side view of the apparatus of Fig. 2 through section R–R in Fig. 3;

Figure 5 shows a pictorial view of the positioning of the collector/separator apparatus.

Figure 6 shows a schematic view of another embodiment of the present invention utilising a collector/separator apparatus:

Figure 7 shows a modification in the use of the apparatus of Fig. 1;

Figures 8a and 8b show a further modification in the use of the apparatus of Fig. 1;

Figure 9 shows a schematic view of a further embodiment of the present invention utilising a collector/separator apparatus.

Figure 10 shows a separator according to a further embodiment of the present invention is sectional side elevation;

Figure 11 shows the separator of Fig. 10 in the collapsed condition for storage;

Figure 12 shows a pressure vessel in sectional side elevation and embodying the present invention through section X–X in Fig. 13

Figure 13 shows a plan view of the pressure vessel through section Y–Y in Fig. 12; and

Figure 14 shows a sectional pictorial view of a modified form of the vessel of Fig. 12.

Referring to Figs. 1 to 4, submersible collecting/separating apparatus 1 for oil/gas/water comprises a vertical open-bottomed vessel 2 having therein equipment for separating the issuing oil from sea water. This separating equipment comprises a vertical array of annular petal plates 4 located below a frusto-conical baffle 3 positioned in the head of the vessel, and each plate 4 is of undulating form having a pair of opposed B-form troughs 60 on the plates upper surface extending radially and downwardly from a central aperture 61 of each plate 4. As a consequence of these troughs 60 crests or ridges 62 are formed whereby opposed open-bottomed channels 63 are created extending radially and upwardly from the central aperture 61 on the lower surface of the plate. A vortex inducing spiral 5 carried by a central tube extends upwardly through the central apertures 63, and at the upper end there is located a hollow central column 13. Reverse bend portions 25 at the top of the column serve to knock-out liquid from the oil/water/gas mixture, and drain tubes 26 within column 13 allow drainage of the liquids. Ports 30 serve for recycling oil/liquid mixture to the petal plates 4. The sense of the vortex blades will depend on the locality (hemisphere) of the apparatus.

The vessel 2 is of square cross-section (see Fig. 3) with a pyramidal top 2A, and the downwardly directed troughs 60 discharge into two opposed corner zones 64 while the channels 63 discharge into the two remaining corner zones 65. A frusto-conical catchment mouth 6 is positioned and supported at the bottom of the vessel 2 by tie rods. Buoyancy tanks 7 with connected remote controlled high pressure air/nitrogen bottles 8, are secured to the vessel and serve for "floating" the vessel at the desired depth, while mooring attachments or remote controlled winches 9 receive mooring wires 10 which are attached to chains 11 for appropriate location of the vessel. In Fig. 2A, duct 6A prevents recirculation of separated water.

To reduce the tendency for the oil and water to form an emulsion (in such a condition separation of oil would be considerably more difficult), demulsifying agents are applied to the water/oil/gas mixture prior to the plates 4 by means of supply line 27 and injection ring 28, 29 is an inlet screen.

In use, gas and oil collect at the closed end of the vessel above the water level, forming an upper gas layer 12 and an oil layer 14, and outlet ducts 15, 16 are positioned at the level of these layers 12, 14 to receive pipelines 17, 18 for delivery of gas and oil respectively to a burn-off or storage means. The ducts 15, 16 include valves 19, 20 controlled by internal level controllers 21, 22 located across the gas/oil level and oil/water level respectively.

For location of the vessel for emergency use, a remote controlled vent valve 23 and a lifting ring 24 are provided to assist with initial installation at an offshore oil leak, mooring point 41 (Fig. 2) are pre-established in the sea bed at several selected positions around the leak 42 as feasible. These can be gravity mooring (e.g. concrete blocks), anchors, or piles driven into the sea bed or any combination of these and chains 10 are attached.

In the event of a blow out, or other leak at or near the sea-bed, the conductor pipe is removed and the unit may be installed as per the sequence shown in Fig. 5 wherein:— the separator (with its flexible oil and gas lines already attached and its vent valve 23 open) is put in a non-buoyant mode by venting the air/nitrogen from tanks 7 and is lowered from its support ship 45 by wire 46 to the sea bed near the leak 42.

Chains 10 are led from the mooring points 41 towards the separator 1 and winch wires 11 from the separator are attached to these chains, and the winches are controlled by signal along its umbilical connection cable 47. High pressure air/nitrogen can be released from bottles 8 into flotation tanks 7 and the separator allowed to rise to position II and then be winched across to its required posi-

tion III. This whole operation may be illuminated and monitored by divers, a submersible vessel or a sub-sea vehicle 48 (Fig. 5) on the sea bed. Fig. 5 shows the movement of the separating apparatus 1 from the initial sea-bed position I (dashed lines) through intermediate position II to final operational position III. In reliably calm water it might be possible to winch the buoyant separator into position over the leak using blocks on the mooring points 41 and winches in the support ship(s) and thereafter either buoy or otherwise lock the winch wires/chains in position. Once in position the separator valves 19, 20 can be opened and vent valve 23 closed the flow would be by flexible lines 17, 18 to:—

I) a ship/barge 43 to accept the separated oil

II) a remote flare 44 or device to accept the separated gas. Water mud and other non buoyant materials would simply fall from the open bottom of this separator 1.

In operation of the separator, the vortex inducing vanes 5 on the central tube will give some centrifugal separation to the rising water/oil/gas mixture, and oil and water is thrown radially outwardly into the spaces between the petal plates 4. Oil will flow outwardly and upwardly in the channels 63, collecting under each of the ridges 62 where it will continue to rise to the opposite corner zones 65 of the apparatus. The sea water on the other hand will flow outwardly and downwardly in the troughs 60 to the corner zones 64. Gas will be taken from the top of the vessel having passed the reverse bend portions 25 which will knock-out further entrained liquid. Oil will be taken from a lower level from corner zones 65 into which channels 63 discharge, while water will sink mainly in the corner zones 64 and will be discharged over the catchment cone 6. Liquid knocked out of the water/gas mixture by the reverse bends 25 may either run down the vessel wall or down pipes 26 within column 13 and can be subsequently recycled.

Dependent upon the depth, at which this tethered sub-sea separator is located, would be the need for further oil/gas separation in the connected ship/barge 43. This same unit could be used for productively harnessing any sub-sea oil leaks, e.g. formation, riser or pipeline leaks. The use of this unit would mean that pipelines might continue to be used long after a leak developed and before a repair could be organised.

The weight of the anchor cables 11 or chains 10 in catenary provides damped flexibility to the vessel 1. Instead of a moored ship 43, the oil pipe 18 could be taken to a single anchor leg mooring (SALM) or other loading device around which the ship swings, but the precise arrangement would depend on location, duty and availability.

Fig. 6 shows an alternative application wherein a leak 49 has developed in riser pipe 50 which is clamped to a platform jacket leg 51. In this instance the catchment cone 6 is removed from the separator 1 and is replaced by a suitable open bottomed catchment can 52 connected by a pipe 53 to the inlet flange on the bottom of the separator. The separator 1 and Can 52 are attached by brackets and chains to clamps 54 on the structure. In this case the can would need to be made in two parts with a hinge 55 and a closure device 56, but since it is open bottomed it is not a pressure vessel and the sealing of the joint between the two parts and around the opening for the riser may be simply effected.

Fig. 7 shows the use of the separator apparatus 1 in conjunction with a canopy 66 to extend the catchment facility of the cone 6, the canopy 66 being winched out by means of blocks and tackle 67. The canopy may even replace the cone 6 and could be extended by other means.

Figs 8*a* and 8*b* shows the use of an ancillary bellows curtain 68 with the separator apparatus 1 and for location on the sea bed at the leakage point. The curtain is slidably located on cables 69 by hoops 70, the cables 6, 9 carrying a heavy ballasting ring 71 made for example from concrete. Fig. 8*a* shows the folded curtain 68 being transported by ships 72. The curtain 68 is subsequently placed around the link at the blow-out and extended upwardly: the separator 1 is then located in position as in Fig. 8*b*. The curtain 68 reduces the seawater entrainment in the rising gas/oil stream, while remaining at hydrostatic pressure.

Fig. 9 shows the use of the apparatus 1 to catch and separate leakage oil from a leak actually occurring under the platform. In this case a deflector plate 73 is utilised and may be incorporated during the construction of the platform jacket. As can be seen the platform conductor pipes 74 pass through glands 75 at the plate 37, but these glands 75 could be fairly simple and robust since they need not be pressure fittings but solely gas deflectors to prevent migration of hydrocarbons under the platform with attendant fire risk.

Separator units could be fabricated and held as emergency equipment by oil Companies operating offshore, or may be incorporated into oil production systems.

Figs. 10 and 11 show an embodiment of the invention comprising a separator similar to that of Figs. 1 to 4 but which is collapsible for storage. Thus the vessel wall 2 is of flexible concertina form including reinforcing hoops 39. Further, the mouth 6 is of flexible material provided with reinforcing hoops 38, and the mouth 6 and the vertical array of petal plates 4 are supported by wires 37 enabling close stacking of the plates 4 in the collapsed condition as can be seen in Fig. 11. The separator is placed in the extended condition

by putting the tanks 7 into the buoyant mode so creating a tension in the mooring wires 10. The plates 4 include central vortex inspiring blades 36.

Figs. 12 and 13 show a separation pressure vessel for the separation of for example gas and oil from an oil/gas/water mixture. The vessel has a hemispherical top 80 and an annular trough 81 at the bottom feeding into a central discharge 82 and the vessel houses a vertical array of petal plates 4 as previously described. The gas/oil/water mixture is pressure fed via pipe 83 to the vessel and the vortex in the separator is produced by a bladed rotor at inlet 35, although of course other means could be used for vortex inspiration such as the means 36 shown in Figs. 10 and 11 or by shaping the inlet pipe to act as a nozzle. As before separator gas is discharged at outlet pipe 17 while separator oil is discharged via pipes 18: the water/solids residue is discharged via line 82. The separator pressure vessel of Fig. 14 is generally similar but utilises individual outlet conduits 84 from trough 81 connecting with outlet pipe 82. Level controls would be required for the gas/oil/water interfaces as before but these are not shown in Figs. 12 to 14.

Further modifications are of course possible in the apparatus. For example, the equipment for separation of the oil from the sea water could take some other form than the array of petal plates.

CLAIMS

1. A method of gathering gas, oil and like substances from a subsea leakage or production/issuing zone comprising submersing a collecting vessel and mooring or fixing the vessel closely adjacent the point of issuance or leakage, permitting the issuing substances to flow into the collecting vessel, causing separation of substances in the vessel and delivering separated substances from the vessel to a storage or disposal means.

2. Apparatus for collecting subsea production issuing or leakage oil, gas and like substances comprising a vessel for submersion in the sea including means for locating the vessel adjacent the zone of issuance or leakage, collecting means in the vessel for collecting substances issuing at said zone means for separating issuing substances from sea water and means for connecting a pipeline to the vessel to permit collected substances to be delivered from the vessel to a storage, transportation or disposal means.

3. Apparatus as claimed in claim 2, wherein the vessel comprises an open bottomed vessel, and said means for locating the vessel includes attachment members for attaching mooring cables to the vessel.

4. Apparatus as claimed in claim 2 or 3, wherein the separating means comprise a vertical array of plates each defining a series of troughs and open bottomed channels.

5. Apparatus as claimed in claim 4, wherein the troughs and channels are inclined from the horizontal, so that in the separation of oil from sea water, oil will flow up the open bottomed channels of one plate to a collecting zone while water will descend in the troughs of the adjacent lower plate.

6. Apparatus as claimed in claim 4 or 5, wherein there is provided a vertical array of annular undulating plates, each plate having a central aperture through which issuing substances flow, the undulations on each plate being arranged such that there are provided a pair of opposed downwardly inclined troughs on the plate upper surface and a pair of opposed upwardly inclined open-bottomed channels on the plate bottom surface.

7. Apparatus as claimed in any one of claims 4 to 6, wherein the separation means is associated with a vortex, inducing spiral means.

8. Apparatus as claimed in claim 7, wherein vortex inducing means are located on a vertical column extending upwardly through central apertures of the plates.

9. Apparatus as claimed in any one of claims 2 to 8 wherein the vessel includes buoyancy means to assist location of the vessel at the desired depth.

10. Apparatus as claimed in any one of claims 2 to 9, wherein a frusto-conical or other suitable inlet mouth is provided at the vessels open bottom to assist collection of substances.

11. Apparatus as claimed in any one of claims 2 to 9 wherein the vessel has means to permit securement of the vessel to an adjacent fixed structure, for example, an oil-rig leg, during operation of the vessel.

12. Apparatus as claimed in claim 11, wherein the vessel fluidly communicates with an initial collector member additionally adapted for securement to said fixed structure.

13. Apparatus as claimed in claim 10, wherein the collector member is in the form of a deflector plate.

14. Apparatus as claimed in any one of claims 2 to 13, wherein means are provided for applying treatment material to the mixture of substances to be separated, prior to entry to the separation means.

15. Apparatus as claimed in any one of claims 2 to 9, wherein curtain or canopy means are provided to assist the flow of substances into the vessel.

16. A separation device for material treatment apparatus including a vertical array of annular plates each providing radially and downwardly directed troughs on an upper surface and radially and upwardly directed channels on the plates lower surface.

17. A method gathering gas oil and like substances as claimed in claim 1, and substantially as hereinbefore described.

18. Apparatus for collecting subsea production issuing or leakage oil, gas and like substances substantially as hereinbefore described with reference to and illustrated in any one of the accompanying drawings.

19. A separation device for material treatment apparatus substantially as hereinbefore described with reference to and illustrated in any one of the accompanying drawings.

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